METHOD AND APPARATUS FOR PROVIDING AN ALERT WITH INFORMATION SIGNAL BETWEEN A MOBILE SWITCHING CENTER AND A BASE STATION

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to spread spectrum telecommunications systems. More particularly, the present invention relates to a novel and improved messaging method and apparatus in a CDMA communication system.

II. Description of the Related Art

The use of code division multiple access (CDMA) modulation techniques is one of several techniques for facilitating communications in which a large number of system users are present. Although other techniques such as time division multiple access (TDMA), frequency division multiple access (FDMA), and amplitude modulation (AM) schemes such as amplitude companded single sideband (ACSSB) are known, CDMA has significant advantages over these other techniques. The use of CDMA techniques in a multiple access communication system is disclosed in U.S. Pat. No. 4,901,307, entitled "SPREAD SPECTRUM MULTIPLE ACCESS COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS," assigned to the assignee of the present invention and incorporated by reference herein.

In the CDMA cellular system, a large number of mobile telephone system users, each having a transceiver, communicates through satellite repeaters or terrestrial stations which are also referred to as cells. Each cell includes a physical plant called a base station. A cell covers a limited geographic area and routes calls carried over cellular telephones to and from a telecommunication network via a mobile switching center. When a cellular telephone user moves into the geographic area of a new cell, the routing of that user's call may be eventually made through the new cell by a process called a "handoff."

A cellular telephone or, more specifically, a mobile station, broadcasts a signal that is received by a base station. The signal is then relayed to a mobile switching center which in turn routes the signal to the public switched telephone network and to telephone lines or other mobile stations.

Similarly, a signal may be transmitted from the public switched telephone network to a mobile station via a base station and a mobile switching center. The communications channel allocated for communication of information between the mobile station and the base station is called the traffic channel.

The interface between the mobile station and the base station is referred to as the Air-Interface. The telecommunications industry association (TIA) has provided a standard for CDMA call processing on the Air-Interface entitled "IS-95-A Mobile Station - Base Station Compatibility Standard for Dual Mode Wideband Spread Spectrum Cellular System," hereinafter IS-95-A, which is incorporated by reference. The interface between the base station and the mobile switching center is referred to as the A-Interface. The TIA has provided for call processing on the A-Interface through the standard provided in "IS-634 Mobile Switching Center - Base Station Interface for Public 800 MHz," which is also incorporated by reference. IS-95-A and IS-634 both define the messages and signals that are sent on their respective interfaces for the operation of a CDMA cellular telephone call.

The call flow in a CDMA environment requires processing on both the Air-Interface and the A-Interface. The successful progression of a call requires that the proper messages and signals are sent at the right times on both the Air-Interface and the A-Interface. The IS-634 standard is being developed to provide for call processing on the A-Interface. A number of problems and deficiencies are present in IS-634 which currently does not support some of the necessary operations on the A-Interface. Some of these problems and deficiencies are recognized and solved by the present invention in the manner described below.

SUMMARY OF THE INVENTION

The present invention is a novel and improved method and apparatus for providing a new message on the interface between a mobile switching center and a base station, also known as the A-Interface, of a cellular telephone system. The present invention recognizes that the A-Interface, as presently defined by the IS-634 standard, does not support some of the operations necessary for reliable call processing. Introduction of the new message will provide support for required functionality on the A-Interface.

The present invention recognizes that improvements are needed for the A-Interface to reliably handle the call waiting and the hard handoff

procedures. In addition, a better technique is needed for resolving a glare condition. An Alert With Information Message is introduced on the A-Interface to improve the operation of these procedures.

Using the call waiting feature, a mobile station may have a first party of a public switched telephone network put on hold while being connected to a second party. If the second party hangs up, then according to the current procedure, a Release/Clear Message (or an equivalent message) is sent to the mobile station, causing the mobile station to release its traffic channel. A new traffic channel must then be reestablished to reconnect the mobile with the first party. The present invention recognizes that the current procedure is unreliable in that difficulties may arise in the process of reconnecting the mobile with the first party. Moreover, Air-Interface resources are used inefficiently as the current procedure requires the release of the traffic channel and the reassignment of a new channel. To overcome these shortcomings, an Alert With Information Message is sent on the A-Interface to the base station, triggering the transmittal of an Alert With Information Message on the Air-Interface. Upon receipt of the Alert With Information Message, the mobile station is prompted to transmit a Connect Message to the mobile switching center via a base station. The mobile switching center then reconnects the first party to the mobile station, without the need to reestablish a new traffic channel.

A hard handoff occurs in a cellular system when a mobile station moves from the coverage area of one base station to the coverage area of another base station. During a mobile station terminated call, in order for the mobile to undertake handoff, it must first receive an Alert With Information Message transmitted by the base station. Under current procedure, the Alert With Information Message is generated and transmitted solely by the base station in whose coverage area the mobile is currently located. The present invention recognizes that the current procedure may cause the hard handoff procedure to be unreliable. If the mobile moves from the coverage area of a first base station to the coverage area of a second base station, the mobile station may never receive the Alert With Information Message from the first base station, resulting in a dropped call. Thus, the present invention provides for an Alert With Information Message to be generated and transmitted by the mobile switching center. While the mobile station is moving from the coverage area of the first base station to that of the second base station, the mobile switching center transmits the Alert With Information Message to the second base station. The second base station in turn transmits an Alert With Information

Message to the mobile station. Having received the Alert With Information Message, handoff can now proceed without the call being dropped.

A mobile subscriber may attempt to originate a call while another party is attempting to call the same mobile subscriber, resulting in a glare condition. The Air-Interface standard, IS-95-A, provides the mobile the option of aborting the call that it is originating and responding to the call that it is receiving. However, the present invention recognizes that the mobile may not successfully receive the call because the base station is not configured to transmit the proper messages to the mobile when a glare condition occurs. In order for the mobile subscriber to respond to a call, it is necessary for the mobile to receive an Alert With Information Message. However, the standard currently does not address this situation. As a result, the call may be dropped. The present invention recognizes that the resolution of the glare condition should be undertaken at the mobile switching center. The mobile switching center, upon receiving a message indicative of a mobile originating a call and subsequently receiving a message indicative of the same mobile receiving a call, should recognize that the mobile is proceeding with receiving a call. The mobile switching center should then transmit an Alert With Information Message to the base station, triggering the base station to transmit an Alert With Information Message to the mobile station. As the Alert With Information Message is received by the mobile station, the glare condition is resolved without the call being dropped.

Benefits and advantages of the present invention will become apparent from the following description of the preferred embodiment when it is considered with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

FIG. 1 is a block diagram presenting a schematic overview of an exemplary CDMA cellular telephone system in accordance with the present invention;

FIG. 2 is a block diagram illustrating an exemplary call-waiting scenario according to the current IS-634 standard;

FIG. 3 is a block diagram illustrating a call-waiting scenario according to the present invention;

FIG. 4 is a flow chart illustrating an exemplary embodiment of the processing steps involved in call-waiting as implemented by the processing elements of FIG. 3;

FIG. 5 is a block diagram illustrating an exemplary hard handoff scenario in a cellular telephone system;

FIG. 6 is a state diagram illustrating the states of a mobile station in a mobile station terminated call;

FIG. 7 is a block diagram illustrating an exemplary embodiment of the hard handoff scenario according to the present invention;

FIG. 8 is a flow chart illustrating an exemplary embodiment of the processing steps involved in hard handoff as implemented by the processing elements of FIG. 3;

FIG. 9 is a block diagram illustrating an exemplary embodiment of the processing elements involved in the resolution of a glare condition; and

FIG. 10 is a flow diagram illustrating the occurrence and the resolution of a glare condition.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An exemplary CDMA cellular mobile telephone system in which the present invention is embodied is illustrated in FIG. 1. The CDMA cellular telephone system is indicated generally by **9** and includes a mobile switching center (MSC) **10**, also referred to as a mobile telephone switching office (MTSO), that includes interface and processing circuitry for providing system control to the base stations. The MSC **10** routes telephone calls from a public switched telephone network (PSTN) **11** to the appropriate base station for transmission to the appropriate mobile station. The MSC **10** also controls the routing of calls from the mobile stations via one or more base stations to the PSTN **11**. In addition, the MSC **10** may direct calls between mobile stations via the appropriate base stations. The MSC **10** may be coupled to the base stations by various conventional means, such as dedicated telephone lines, optical fiber links, or by radio frequency communications.

It should be understood that although the present invention is described herein within the context of a CDMA cellular communications system, it is equally applicable to other types of communication systems,

such as the personal communication system (PCS). Furthermore, systems utilizing other well known transmission modulation schemes such as TDMA and FDMA as well as other spread spectrum systems may employ the present invention.

In FIG. 1, two exemplary base stations (BSs), **12** and **14**, along with two exemplary mobile stations (MSs) **16** and **18**, each including a cellular telephone, are illustrated. Arrows **20a** and **20b** represent forward and reverse code channels that define a possible communication link between BS **12** and MS **16**. Arrows **22a** and **22b** define a possible communication link between BS **12** and MS **18**. Similarly, BS **14** can establish a two-way communication link with MS **18** as represented by arrows **24a** and **24b** and with MS **16** as represented by the arrows **26a** and **26b**.

As previously mentioned, the interface between BSs **12** and **14** and MSs **16** and **18** is called the Air-Interface, and in the exemplary embodiment, call processing on the Air-Interface is governed by IS-95-A. Also as previously mentioned, the interface between MSC **10** and BSs **12** and **14** is called the A-Interface, and call processing on the A-Interface is governed by IS-634. The present invention recognizes that the A-Interface as currently defined by IS-634 lacks support for some of the necessary functionality for reliable call processing. In addition, the present invention recognizes that introduction of a new message on the A-Interface will cure some of the deficiencies of the A-Interface.

An exemplary procedure in which deficiencies are recognized on the A-Interface is the call waiting procedure. Call waiting is one feature available to the CDMA cellular subscriber. The call waiting feature allows a cellular subscriber to toggle between two parties on the telephone network. Call waiting may be provided in a CDMA telephone system according to the techniques disclosed in copending U.S. Patent Application Serial No. 08/535,998, entitled "Early Detection of Mobile to Mobile," filed September 29, 1995, which is assigned to the assignee of the present invention and incorporated by reference herein.

An exemplary call waiting scenario is illustrated in FIG. 2. In FIG. 2, party 1 **28** and party 2 **30** are two parties of a PSTN. A call has been established between MS **32** and party 1 **28**. A traffic channel has been set up between MS **32** and BS **34** on the Air-Interface. Furthermore, BS **34** is connected to MSC **36** on the A-Interface by any of various conventional means as described above.

If party 2 **30** calls MS **32** while MS **32** is communicating with party 1 **28**, MSC **36** will send signaling data to BS **34** indicating that another party is

attempting to contact MS 32. The means for combining traffic data and signaling data is described in detail in U.S. Pat. No. 5,511,073, entitled "METHOD AND APPARATUS FOR THE FORMATTING OF DATA FOR TRANSMISSION," assigned to the assignee of the present invention and incorporated by reference herein. To inform MS 32 that another call is coming in, an alerting signal is relayed by BS 34 to MS 32 either by a Flash With Information message or an inband tone. Then, MS 32 can invoke the call waiting feature by pushing a specific key on the MS keypad. This causes the generation of a Flash With Information Message, which is sent on the Air-Interface to BS 34, which in turn relays the Flash With Information Message on the A-Interface to MSC 36. MSC 36 then connects party 2 30 to MS 32 while putting party 1 on hold. Thereafter, MS 32 may toggle between party 1 28 and party 2 30 by pushing the key on the keypad to cause the generation of the Flash With Information Message. Each time MSC 36 receives the Flash With Information Message, it connects MS 32 to the party that was previously put on hold and puts on hold the party that was previously on the line.

Referring still to FIG. 2, assume that party 1 28 is on hold and MS 32 is connected to party 2 30. If party 2 30 hangs up, then according to the current procedure, the network which is servicing party 2 generates a Release Message. This Release Message propagates to MSC 36, which then sends the Release Message to BS 34 on the A-Interface. BS 34 in turn sends a Release Message to MS 32 on the Air-Interface to cause MS 32 to release its traffic channel. MSC 36 then signals to BS 34 that party 1 28 is attempting to contact MS 32. This causes BS 34 to send a Paging message to MS 32 to indicate that a call is incoming. In response, MS 32 generates a Paging Response Message which is transmitted to BS 34. BS 34 then transmits the Paging Response Message to MSC 36. On receipt of a Paging Response Message, MSC 36 assigns a new traffic channel to MS 32 and MS 32 is reconnected to party 1 28.

The present invention recognizes that this procedure has several shortcomings. First, it does not efficiently use the Air-Interface resource, since it requires the release of the traffic channel, re-paging of MS 32 and the assignment of a new traffic channel. Further, the need to obtain a new traffic channel makes it difficult to reestablish the connection between MS 32 and party 1 28. If MS 32 moves away from BS 34 from which it is released, the page from MSC 36 may not be received by MS 32. At the very least, this increases the amount of time that party 1 28 has to wait for the reconnection with MS 32. There is also the possibility that the connection between MS 32

and party 1 **28** cannot be reestablished, resulting in a dropped call. A better procedure is needed to handle the procedure for releasing party 2 **30** from MS **32** wherein MS **32** is using the call waiting feature.

To overcome the shortcomings, the present invention introduces a new message for the A-Interface. A preferred embodiment of the present invention is illustrated in FIG. 3. The preferred embodiment provides for a new message, an Alert With Information Message, on the A-Interface. The Alert With Information Message is currently available on the Air-Interface under IS-95-A. According to IS-95-A, the Alert With Information Message is sent by a base station to a mobile station to cause the mobile to ring and to transition from a Conversation State to a Waiting For Answer State, expecting the mobile user to intervene. By providing for an Alert With Information Message on the A-Interface, the mobile switching center can better control the progress of the call waiting procedure.

Referring to FIG. 3, assume again that party 1 **28** is on hold and MS **32** is in communication with party 2 **30**. If party 2 **30** then hangs up, the network servicing party 2 **30** generates a Release Message as described above. In the preferred embodiment, when the Release Message comes from the network, MSC **36** intercepts it, and message generator **38** in MSC **36** generates an Alert With Information Message signal, which is sent to BS **34** on the A-Interface. Message receiver **40** in BS **34** receives the Alert With Information Message, and BS **34** in turn sends an Alert With Information Message to MS **32** on the Air-Interface. When MS **32** receives the Alert With Information Message, it generates an alerting signal in the mobile and waits for the subscriber to answer. When the subscriber answers by pressing a key on keypad of MS **32**, a Connect Message generated by MS **32** is sent to BS **34** and forwarded to MSC **36**. On receiving the Connect Message, MSC **36** connects party 1 **28** to MS **32**.

In the preferred embodiment, by not permitting the Release Message (or a Clear Message) from the network to be sent to MS **32**, MS **32** is not caused to release the traffic channel when party 2 **30** hangs up. As a result, there is no need to expend additional Air-Interface resources for the assignment of a new traffic channel. Furthermore, the preferred embodiment does not require MS **32** to be paged following the release of the traffic channel to indicate that party 1 **28** is still waiting to be reconnected with MS **32**. Consequently, the risk that MS **32** will move away from the coverage area of BS **34** and not receive the page is eliminated.

A brief illustration of the steps involved in call waiting as described in the embodiment above is shown in FIG. 4. FIG. 4 shows a flow chart

illustrating some of the steps involved in the processing as discussed with reference to FIG. 3.

Another procedure in which deficiencies are recognized on the A-Interface is the handoff procedure. In a cellular communication system, a handoff must take place when a mobile station moves from the coverage area of one base station to another base station. A geographic area in a cellular system is divided up into cells. Each cell is serviced by a corresponding base station. In a hard handoff environment, as a mobile station moves from one cell to another cell, communication with the original base station is terminated before communication with the subsequent base station is established. In a soft handoff environment, communication with the subsequent base station is established before terminating communication with the original base station. U.S. Patent No. 5,267,261, which is incorporated by reference and assigned to the assignee of the present invention, discloses a method and system for providing soft handoff.

The hard handoff procedure in a mobile terminated call may be understood with reference to FIGS. 5 and 6. As illustrated in FIG. 5, as MS **42** moves from the coverage area of BS1 **44** to BS2 **46**, a connection needs to be established between MS **42** and BS2 **46** while MS **42** needs to be disconnected from BS1 **44**. Both BS1 **44** and BS2 **46** are shown to be connected to MSC **48** in FIG. 5. However, it should be understood that a hard handoff can also occur when a mobile station moves from the control of one mobile switching center to another. In fact, the different mobile station controllers may support different modulation techniques such as TDMA or FDMA.

In FIG. 6, the states of a mobile station in a mobile terminated call are briefly illustrated. The states are summarized herein and explained more fully in the aforementioned document IS-95-A, pages 6-160 to 6-161.

The progression of the hard handoff procedure is dependent on the state of the mobile station. Referring to FIG. 6, in a mobile station terminated call, the mobile is in the Traffic Channel Initialization State, shown by block **50**, when a traffic channel has been established between a mobile station and a base station. Upon receipt of a Base Station Acknowledgment Order from the base station, the mobile moves into the Waiting For Order State, shown by block **52**. The mobile station then transitions into the Waiting For Answer State, illustrated by block **54**, when it receives an Alert With Information Message from the base station. When the mobile station subscriber answers the call by pushing a specific key on the mobile station keypad, the mobile transitions into the Conversation

State, represented by block **56**. The mobile transitions into the Release State, shown by block **58**, when conversation terminates.

According to the current procedure, a mobile station should be in the Waiting For Answer State **54** or the Conversation State **56** during hard handoff. If the mobile is in any other state, the call is likely to be dropped during hard handoff. Thus, the mobile station must receive an Alert With Information Message transmitted by the base station on the Air-Interface before the mobile station undertakes handoff. Otherwise, the handoff procedure would be unreliable. Referring again to FIG. 5, assume that MS **42** is in the coverage area of BS1 **44**. If MS **42** subsequently moves from the coverage area of BS1 **44** to the coverage area of BS2 **46** while MS **42** is in the Waiting For Order State **52**, MS **42** may not receive the Alert With Information Message sent by BS1 **44**. Without receiving the Alert With Information Message, MS **42** cannot transition into the Waiting For Answer State **54** in the coverage area of BS2 **46**. As a result, the call will be dropped while handoff is in progress. Thus, the present invention recognizes that a better method for handling hard handoff in a mobile station terminated call is necessary.

As previously described, providing an Alert With Information Message on the A-Interface overcomes the shortcomings in the call waiting procedure. The present invention recognizes that providing an Alert With Information Message on the A-Interface will also overcome the shortcomings in a hard handoff procedure in a mobile station terminated call. Further, it should be understood that the present invention applies to hard handoff procedures in a variety of communication environments, including CDMA, TDMA, or FDMA.

A preferred embodiment of the use of an Alert With Information Message on the A-Interface in a hard handoff procedure is illustrated in FIG. 7 with reference to FIG. 6. An Alert With Information Message is generated by message generator **50** in MSC **48** and sent to message receiver **52** in BS2 **46**. The Alert With Information Message is sent on the A-Interface when MS **42** is moving from the coverage area of BS1 **44** to the coverage area of BS2 **46** while in the Waiting For Order State. After BS2 **46** receives the Alert With Information Message from MSC **48**, BS2 **46** then sends an Alert With Information Message to MS **42** on the Air-Interface. Having received the Alert With Information Message, MS **42** can transition into the Waiting For Answer State **54** while in the coverage area of BS2 **46**, and handoff can occur without the call being dropped. Thus, by providing for an Alert With Information Message on the A-Interface, MSC **48** has better control of the

hard handoff procedure. Since MSC **48** can send the Alert With Information Message to BS2 **46**, causing BS2 **46** to send the Alert With Information Message to MS **42**, MS **42** does not need to rely on receiving the Alert With Information Message from BS1 **44** in order to transition into the Waiting For Answer State **54**. Consequently, handoff can occur without the call being dropped. A flow chart illustrating some of the processing steps involved in hard handoff as described in the embodiment above is shown in FIG. 8.

Still another procedure in which deficiencies are recognized on the A-Interface is the handling of a glare condition. A glare condition ~~may occur~~ is when a mobile subscriber attempts to initiate a call while another party is attempting to call the mobile subscriber. A call initiated by a mobile subscriber is referred to as a mobile station originated call, while a call made to a mobile subscriber is referred to as a mobile station terminated call.

The glare condition may be better understood by referring back to FIG. 1. In a mobile station originated call, an Origination Message is transmitted from a mobile station, such as MS **16**, to a base station, such as BS **12**, upon initiation of a call by MS **16**. After transmission of the Origination Message but before a connection is established between MS **16** and the called party (party A of PSTN **11**), another party (party B of PSTN **11**) may attempt to contact the mobile subscriber and MSC **10** may page MS **16**, ~~resulting in~~ causing a glare condition. The Air-Interface standard, IS-95-A, permits MS **16** the option of aborting the call to party A and responding to the call from party B. MS **16** then follows the state transition sequence for a mobile station terminated call as illustrated in FIG. 6.

Referring now to FIG. 6, in a mobile station termination scenario, the mobile expects to receive an Alert With Information Message to transition from the Waiting For Order State, represented by block **52**, to the Waiting For Answer State, represented by block **54**. If the Alert With Information Message is not received, the mobile would time out and release the call.

It is recognized by the present invention that current procedures under IS-95-A and IS-634 do not properly resolve the glare condition. Currently, the base station is not configured to transmit an Alert With Information Message to the mobile station upon occurrence of a glare condition. The problem is explained in greater detail with reference to FIG. 9. Referring to FIG. 9, when MS **60** originates a call, an Origination Message is sent from MS **60** to BS **62**. In response to the Origination Message, BS **62** transmits a BS Acknowledgment Order to MS **60**. Meanwhile, MSC **64** receives an incoming call to the same MS **60**, unaware of the origination

effort in progress, and sends a Paging Request Message to BS **62** to initiate a mobile terminated call setup. BS **62** in turn sends a Page Message containing the MS address, and the Page Message is received by MS **60**.

Due to the mobile origination attempt, BS **62** constructs a Service Request Message and sends the message to MSC **64**. However, after receiving the Page Message, MS **60** aborts the origination call setup, and responds by transmitting a Paging Response Message, which is received by BS **62**. But because MSC **64** had received a Service Request Message from BS **62**, MSC **64** in response sends an Assignment Request Message to BS **62**, requesting assignment of Air-Interface resources for the mobile station originated call. Upon receipt of the Assignment Request Message, BS **62** assumes that a mobile station originated call is in progress, and does not transmit an Alert With Information Message to MS **60**. As a result, MS **60** times out waiting for the Alert With Information Message, and the mobile station terminated call is dropped.

In order to better resolve the glare condition, the present invention provides for still another use of the Alert With Information Message on the A-Interface. First, note that after BS **62** receives a Paging Response Message from MS **60**, BS **62** in turn sends a Paging Response Message to MSC **64**. Then, in a preferred embodiment, the present invention provides for an Alert With Information Message to be transmitted on the A-Interface if MSC **64** receives a Service Request Message and then a Paging Response Message. Still referring to FIG. 9, it can be seen that the Alert With Information Message may be generated in MSC **64** by message generator **66**, while the Alert With Information Message may be received in BS **62** by message receiver **68**. After BS **62** receives the Alert With Information Message from MSC **64**, BS **62** then sends an Alert With Information Message to MS **60** on the Air-Interface. Having received the Alert With Information Message, MS **60** can transition into the Waiting For Answer State, and the glare condition is resolved without the call being dropped.

Referring now to FIG. 10, a flow chart illustrating some of the processing steps involved in the resolution of the glare condition as discussed with reference to FIG. 9 is shown. An Alert With Information Message is provided on the A-Interface to resolve the glare condition.

The present invention recognizes that for the call waiting, hard handoff, and resolution of a glare condition procedures, there are certain deficiencies in call processing on the A-Interface as currently defined by IS-634. By providing an Alert With Information Message on the A-Interface, the present invention overcomes these deficiencies. The Alert With

Information Message is already available on the Air-Interface under IS-95-A to cause a mobile station to transition from the Waiting For Order State to the Waiting For Answer State. An Alert With Information Message is provided on the A-Interface to trigger the transmittal of the Alert With Information Message on the Air-Interface, solving the problems of the call-waiting and handoff procedures as well as resolving the glare condition.

The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

I CLAIM: